

The ARC Training Centre for Innovative Wine Production:

People and Projects

1a. Optimisation of an early harvest regime – impact on grape and wine composition and quality

Researcher: Olaf Schelezki



One approach to reduce the alcohol level in wine involves several portions of the crop being harvested at an under-ripe stage and fermented to a lower alcohol blending material. Unlike water, this blending material can then legitimately be incorporated in any proportion into the wine produced from the remainder of the fully ripened crop to decrease the potential ethanol content (and pH) of the must. In this project, wines produced by sequential harvest will be chemically and sensorially compared to wines with similar alcohol levels made from grapes harvested at specific °Baume. Treatments will be tested by descriptive analysis to examine limiting thresholds for ethanol reduction, and finally, to address whether it

is better to reduce ethanol by blending or simply to pick the fruit earlier, and what is the potential of either treatment to reduce ethanol without compromising wine quality. Cultivar specific quality attributes will be tracked back from the glass to the grapes, with consideration of both vintage effects and the influence of temporal variability of the berry population on grape and wine composition, to provide deeper insight into components related to quality other than sugar that can be targeted for more precise harvest decisions.

1b. Application of reverse osmosis/perstraction to wines made from grapes with different levels of maturity: chemical and sensory evaluation

Researcher: Rocco Longo



This project will use a combined approach that involves a sequential harvest regime and blending of dealcoholized wines. Targeted grape harvests will be subjected to membrane separation technologies, such as reverse osmosis and evaporative perstraction, to achieve wines with reduced level of alcohol. This research will investigate viticultural and wine production approaches that will enable the production of lower ethanol wines that retain the compositional components responsible for the enjoyment of wines that have naturally occurring higher alcohol concentrations.

2. The sugar-potassium nexus within the grape berry

Researcher: Zelmari Coetzee



Management practises targeted at lowering the sugar content of grapes include harvesting earlier at a lower Baumé, managing irrigation, or choosing varieties that do not accumulate high concentrations of sugar. Conversely, potassium (K^+) can be manipulated in the vineyard through the selection of rootstocks and potentially also by irrigation strategy, and depending on soil type and available K^+ concentrations, by modifying fertilisation regimes. The aim of the project is to investigate the apparent sugar-potassium nexus in ripening grape berries and to determine if it can be manipulated to optimise the berry sugar and K concentration at harvest, without negatively impacting on other aspects, e.g. aromatic development, during ripening. If the sugar content of the grape berry can be lowered by reducing K^+ transport towards the grape berry, it may result in the production of lower alcohol wines due to the

decreased sugar content in the grape juice at the time of harvest. In addition, by lowering the berry K^+ content at harvest, there would be a consequential reduction in grape juice pH and reduced requirement for the costly practise of adjusting pH by the addition of tartaric acid.

3a. Cell death in the berry and berry weight loss

Researcher: Dr Simon J. Clarke



Mesocarp cell death in some grapevine varieties could influence flavour and aroma development, extractability of the juice, berry water relations, sugar concentration, and ultimate wine quality. Cell death is potentially important to the production of lower alcohol wines because vital grape berry cells are thought to be necessary for maintaining a high water content in the fruit. Vital berry cells promote water inflow from the parent plant, compensating for water lost to the atmosphere through the berry surface. In the absence of vascular inflows, the fruit water content will decrease and the concentration of solutes will increase. The concentrated sugars resulting from these processes are anticipated to increase the alcohol content of wine.

The general aim of this research, as well as the two projects described below, is to provide fundamental information on the processes responsible for inducing grape berry cell death. The aim of this particular research is to identify viticultural practices with the potential to delay or enhance grape berry cell death. This research will proceed by assessing whether processes extrinsic to the grape berry (such as canopy manipulations) have an effect on berry cell death. The research will then turn to assess the role of intrinsic berry characteristics (such as developmental stage) on berry cell death. These paired experimental themes will be used to identify where scope exists for manipulating berry cell death in the vineyard.

3b. Investigation of the physiological cause of grape berry cell death

Researcher: Zeyu Xiao



Cell death in grape berries is linked to berry shrivel for some varieties late in ripening. This event is hypothesized to affect quality, fermentable sugar content due to shrivel, and juice extractability of the berries. Oxygen depletion is one of the key determinants influencing plant physiological processes, especially in non-photosynthesizing organs. Pericarp cells may be under hypoxic/anoxic stress during the late ripening stages, due to reduced gas exchange across the exocarp and respiratory consumption of oxygen. The resultant oxygen shortage restricts aerobic respiration causing a rapid change in the intracellular energy status, which could impact on cell metabolism, ultimately with effects on biochemical reactions and solute partitioning, and tissue vitality. Grape berry internal oxygen status, as

well as changes in berry metabolism during ripening will be examined using cutting-edge oxygen microelectrode techniques. This project also aims to establish the potential links between berry cell death and wine quality.

3c. Molecular events underlying death in grape berry

Researcher: Siyang Liao



Cell death is characterized by a breakdown of cell membrane integrity. In order to assess the broader impact of cell death on berry quality it is important to gain a better understanding of the mechanisms underlying cell death. It is still not clear if cell death in the berry is apoptosis-like (programmed) or necrosis. Reactive oxygen species are versatile signalling molecules playing an essential part in regulating plant apoptosis-like cell death, of which the loss of cell membrane competence is one of several hallmarks. In this project, mesocarp cell death in the grape berry will be examined to determine if it is an apoptosis-like cell death. The potential role of reactive oxygen species in cooperation with other cell death specific signalling molecules and gene signalling pathways will be investigated.

4. The biochemical response of grapevines to smoke exposure

Researcher: Lieke van der Hulst

Global warming is increasing the frequency of heatwaves and the incidence of bushfires. In some instances, fires are occurring in close proximity to wine regions, resulting in vineyard exposure to smoke. Grapes from smoke-exposed vines can be tainted, and so too can the resulting wines, making them unsaleable, and a significant challenge to grapegrower and winemaker viability in fire-prone areas.



Previous research has demonstrated that smoke derived volatile compounds accumulate in grapes in glycoconjugate forms, i.e. with one or more sugar moieties attached. This complicates both the detection of smoke taint in fruit and the amelioration of smoke taint from wine, and is also thought to be the reason that smoke taint intensifies in wines with bottle age. This project therefore aims to investigate the biochemical response of grapevines to smoke exposure; in particular, the enzymes responsible for glycosylation of smoke derived volatiles in grapevine fruit and leaves following exposure to smoke. The outcomes of this research will aid

development of practical solutions for eliminating smoke taint in wine.

5. Programmed cell death in grape berries/Communication between yeast and grapevine

Researcher: Dr Shifeng Cao



Grapevine surfaces provide a physical environment suitable for the growth of microbial communities that depend on the grapevine for nutrients, water and protection. Yeast populations are spatially distributed over the grapevines and are dynamic during the course of grape development. The community dynamics is also influenced by external factors such as geographical location, climatic conditions, grape cultivar, vine canopy and the use of agrichemicals. It has been clearly established that phytopathogenic fungi, bacteria, and viruses exert biotic stresses on plants. Much less is known, however, about the interactions between oenological species of yeast and their host plants. Although evidence exists that *S. cerevisiae* was a potential pathogen towards

grapevine, to date there have been no reports that indicate that the association of the yeast with plants changes physiological conditions leading to restricted entry of pathogens through stomata or cell wall. To test this assumption, we will examine the importance of stomata and fruit cell wall in the phytopathogenicity of yeast towards grapevines and reveal previously unknown feature of grapevines' behaviours in response to yeast attack. The mechanisms observed here may be of significant ecological importance and may help to explain the long periods of yeast survival found to occur in vineyards.

6. Managing ethanol and sensory compounds by non-Saccharomyces yeasts

Researcher: Ana Hranilovic

This project intends to focus on exploring non-Saccharomyces biodiversity to select yeasts capable of diverting sugar from ethanol to other favourable or flavour-active end-products.

The major objective is to define yeast strains and oenological practices leading to lower ethanol yield in high sugar must fermentations.



Use of newly selected and improved non-*Saccharomyces* strains will lead to the establishment and implementation of more efficient methods for ethanol reduction, alongside reduced risk of quality loss. This approach, permitted in the current legislative setting, is highly economically feasible and environmentally viable, as it does not generate additional capital investments and energy inputs associated with conventional methods for ethanol management. Outputs of this project are therefore expected to generate contributions relevant both for the research community and the wine industry.

7. Cyclodextrins – an inert carbon sink for grape sugars

Researcher: Chao Dang



The project aims at exploring the utilisation of specific enzymes to convert fermentable grape sugars (especially glucose) in the must to non-fermentable cyclodextrins, ultimately producing wines with lower alcohol level. Cyclodextrins are non-toxic, naturally occurring, cyclic oligosaccharides formed by the action of certain microorganisms on starch. The utilisation of Cyclodextrin forming enzyme (CGTase), fate of carbon from metabolised sugars, steps to remove the cyclodextrins and the oenological acceptability of the enzyme products will be explored and determined using suitable chromatographic and sensory techniques.

8. Impact of high sugar content on the efficiency and sensory outcomes of uninoculated fermentations

Researcher: Federico Tondini



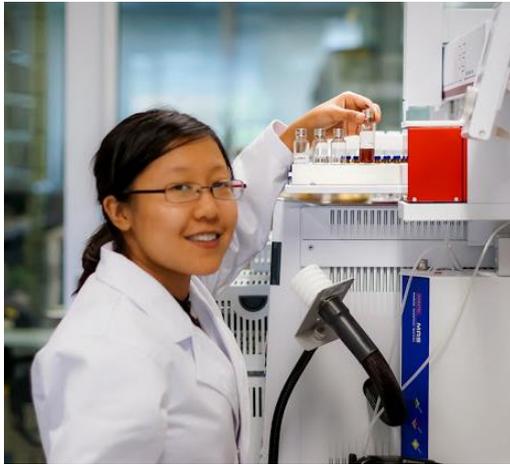
This project aims to uncover how wild yeast populations deal with the wine making condition, particularly with the stressful environment created by high sugar concentrations. Different phenotypes will be identified together with the molecular rationale for their stress response and targets that can be used for the selection. This can ultimately provide a guide for selection of yeast strains with improved resistance to hyperosmotic stress and more desirable metabolic outcomes. Solutions

for problematic fermentations and recommendations for the yeast strains, the type and

condition of fermentation, and the prediction of the final fermentation bouquet would be evaluated.

9. Selective and deliberative use of winemaking supplements to modulate sensory properties of wines

Researcher: Sijing Li

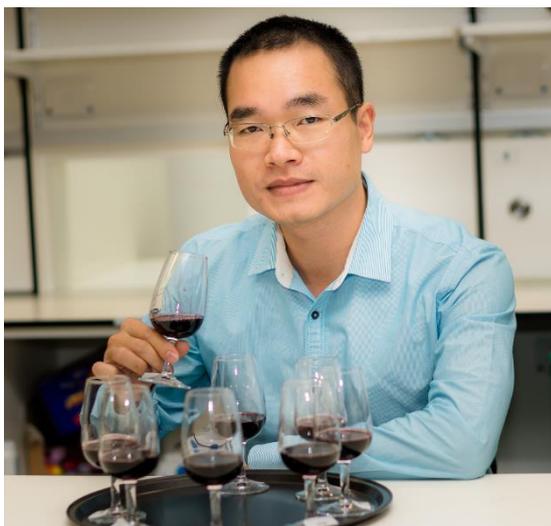


Alcohol reduction can be achieved by several methods prior to, during or post vinification and this project will investigate two specific approaches: (i) an early harvest (12.5 Baumé) and (ii) a harvest at commercial maturity (~14.5 Baumé) with fermentation arrested at various residual sugar levels. The aim of the project is to evaluate the quality of red wines made from the above-described approaches through chemical analysis and sensory evaluation. Maceration enzymes and mannoprotein will be added individually and in combination to determine the optimal addition regime. Different combinations of residual sugar levels and lactisole concentrations will also be trialled to achieve the best sensory outcome. The

results of this project will further wine researchers' and winemakers' understanding of the effect of maceration enzymes and mannoproteins on wine. The results will also help winemakers make informed decisions regarding the timing and dosage of these wine additives, should they choose to use them. The findings will also demonstrate the potential of lactisole as a sweetness repressor in wine; either to produce low alcohol wine or to ameliorate excessive sweetness in stuck fermentations. Ultimately this project will provide winemakers with more tools to produce quality red wines with lower alcohol levels, which are increasingly in demand by consumers.

10a. Getting alcohol content right: The compositional and sensory basis for an alcohol sweetspot

Researcher: Duc-Truc Pham



The wine alcohol "sweet spot" refers to the observation that relatively small changes in a wine's alcohol content can have a substantial effect on its sensory properties. For dealcoholised wine, there often appears to be one or more alcohol concentrations at which the wine seems to exhibit greater flavour intensity and superior overall balance, and thus, is preferred over other concentrations. However, to date, the available scientific evidence does not support these observations. Current sensory research suggests that tasters cannot distinguish wines with less than a 0.4% (ABV) difference and raises questions as to whether the phenomenon exists or is of any commercial significance. This is an issue for all wines but particularly for reduced alcohol

products. Indeed, many of those winemakers who have regularly practised alcohol reduction believe strongly in the idea of the sweet spot and actively target their alcohol reduction to these levels. If the prevailing research is correct, they are wasting their time and effort. If it is not correct, then

winemakers who choose an arbitrary alcohol concentration could be missing an opportunity to optimise the quality of their wine. The aim of this project is to investigate more appropriate sensory evaluation techniques to test the sweet spot phenomenon on a range of wines. Presuming this can be demonstrated, more detailed chemical and sensory analyses will attempt to characterise and explain the changes in marginally reduced alcohol wines.

10b. The alcohol sweet spot phenomenon

Researchers: David Wollan



The wine industry practises ‘alcohol sweet spot’ tastings where winemakers were presented with a range of samples of the same wine with varying concentrations of alcohol. Although the incremental alcohol concentration differences were small, clear favourites seemed to emerge. Surprisingly, these sweet spots exhibited better flavour and balance as well as stylistic differences such that the same wine at selected alcohol concentrations appeared to be preferred. If there are certain sweet spots that are demonstrably favoured by tasters, whether opinion leaders or consumers more widely, then these should be the obvious targets for alcohol reduction.

Unfortunately, current research does not provide any sensory or analytical explanation to support that sweet spots exist. This project will undertake a more focused investigation with the aim of validating the concept and providing practical, but scientifically robust tools for identifying sweet spots for a given

wine. Presuming the phenomenon is real and economically justified, the project will seek some explanation – chemical, physiological or neurological. If this project is successful, it will provide winemakers with the tools to adjust wine alcohol and target the best possible result with confidence.

10. Controlling unripe characters using Molecularly Imprinted Polymers (MIPs) or specific microbes to eliminate methoxypyrazines from wine

Researcher: Chen Liang



Methoxypyrazines (MPs) are primarily responsible for the green characters in wine, displaying green bell pepper, grass, green bean, asparagus and herbal notes. Low concentrations can add varietal flavour, however high concentrations are deemed undesirable and overpowering of the natural fruit berry characters by wine consumers. MPs are produced early in the development of most grape varieties and are largely unaffected by winemaking practices. Recent research has developed novel approaches to reduce methoxypyrazines in wine, such as molecularly imprinted polymers (MIPs). MIPs

are a kind of matrix that possess structural complementary cavities for target molecules. The functional polymer is first templated with the target compound to provide recognition sites that will selectively bind and remove MPs from juice or wine. Using this approach, unripe characters within wine caused by using early harvested grapes can be remediated, which will aid in the beneficial

development of low alcohol wines. The use of magnetic molecularly imprinted polymers will be an innovation and add convenience to practical industrial operations, since they can be removed from a wine by simply applying an external magnetic field. Though some microbes will transform methoxypyrazines into other forms, currently no wine yeasts have been found to have such ability, thus we are also on the hunt to find such new strains to use in combination with the MIPs.

11. Large scale processing of wine components of vinification for the creation of useful products streams

Researcher: Dr Ravichandra Potumarthi



During the 2012 vintage alone, close to 500,000 tonnes of grape marc required a suitable disposal method, with that responsibility resting with the respective wineries. Marc is one of the important by-products from wineries and has the potential to generate revenue from recovered alcohol through marc processing and distillation. However, an opportunity exists to improve the efficiency of the current process by adopting alternate fermentation methods, process optimisations and pre-treatment techniques. This project aims to address process improvement of marc fermentation and its integration with existing distillation processes by undertaking a cost-benefit analysis, characterising marc samples, improving fermentation efficiency, and increasing alcohol yield and quality. Enhancing grape marc processing capabilities will enable

greater conversion of this industry waste stream into a valued product, thereby addressing both environmental and financial sustainability concerns of industry stakeholders.

13. Because you are worth it: Self-sacrifice vs. product authenticity (The case of wine)

Researcher: Bora Qesja



The aim of this study is to investigate the effect of a substantial innovation of a product with a strong traditional and historical heritage, on perceived authenticity and congruence. Consequently, the trade-off (perceived sacrifice) between the innovated product's believed loss of functional benefit and authenticity (if any) will be analysed with flow on effects to purchase intentions (word of mouth and willingness to recommend) and ultimately quantity purchased. The innovation is the manipulation (lowering) of the alcohol level across a number of varieties and styles to be tested. In addition to determining the effect of the innovation on the level of authenticity and congruence, the percentage of alcohol together with the type/colour of wine (red, white, rose, sparkling) and the varieties/styles will be used as variables with the purpose of determining the optimum new product (as perceived by

consumers). Consumer oriented variables, relating to product category usage, involvement etc. will be explored to determine any moderating effect on consumers perceptions and expectations of the product and, ultimately, on its desirability. The study will not only be a contribution to the literature

on authenticity, congruence and low/partially dealcoholized wines but will have managerial implications as it will show how consumers deal with innovations of traditional products. Moreover, it will also be a contribution to the wine industry by providing an insight as to how consumers perceive the innovation as well as what is the 'optimum' innovated product when it comes to low/partially reduced alcohol wine. This would in turn help towards the bigger cause of lowering the alcohol consumption per capita.

14. Translation of "Whole-of-Production-Chain" wine science research to industry outcomes

Researcher: Dr Renata Ristic



Dr Ristic will coordinate research between CSU, UA and remaining industry partners and translate research outputs from all TC-IWP projects into industry-ready applications. The main aim is to assemble the outcomes from a range of flavour and alcohol modulation techniques into an integrated strategy that can be easily implemented in the wine industry. This project is funded by Wine Australia.

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